King Saud University

College of Science

Biochemistry Department

Course title and code: Bioenergetics (BCH 441)

Credit hours: 2 (2 + 0)

Pre-requisite: BCH 340

Lecture time: Tuesday (from 3:00 am to 4:50 pm).

Lecture location: 1 A 39 Bld. # 5

Objectives:

At the end of the course, the students will be able to:

- Define bioenergetics
- State the laws of chemical thermodynamics
- Describe the mechanisms of energy coupling
- Describe the mechanisms by which ionophores promote the transfer of ions across the hydrophobic barriers in membranes.
- Understand the role of adenylate energy charge (AEC) in regulating catabolic and anabolic pathways.
- Describe the mechanisms that explain the high-energy character of high-energy compounds.
- Describe the process of synthesis of ATP by chemiosmosis
- Describe the membrane transport mechanisms
- Explain the thermodynamics of oxidation-reduction reactions and describe the component of electron transport chain (ETC).
- Describe the basic features of chloroplast that facilitate its role in photosynthesis and describe the light reactions of photosynthesis .

Reference Books:

- **Principles of Biochemistry (Lehninger)** by DL. Nelson and MI. Cox (latest edition).

Topics	Contact hours
• **Introduction and definitions:** Energy, work, types of energy, interconversion, equivalence, equilibrium, efficiency the cell as a thermodynamic system. Flow of energy in the biosphere. Food chains, food webs. Classification of cells on basis of carbon source, energy source. Carbon, oxygen and nitrogen cycles. Intracellular flow of energy, role of ATP.	2
• **Introduction to thermodynamics:** Definition of closed systems, steady state, equilibrium state, spontaneous process, total energy of a system, concept of entropy. First and second laws of thermodynamics, concept of Gibbs free energy, distinction between useful energy and random energy. Enthalpy. Definition of terms, endergonic, exergonic, endothermic, exothermic.	2
• **Mathematical relationship:** Between enthalpy, entropy and free energy changes at constant temperature and pressure. Criteria of spontaneity for biochemical reactions. Feature of free energy changes for biochemical reactions. Definition of standard state. Units of free energy. Mathematical relationship between standard free energy change and equilibrium constant.	2
• **Calculation** of ΔGo from Keq or vice-versa with examples. Calculation of ΔG for non-dependence concentrations of ΔG on presence of enzymes and examples.	1
• **Adenosine triphosphate (ATP),** definition of high-energy bonds. High-energy compounds. Phosphate group transfer potential. Central role of ATP in energy transfer. Structure of ATP, change of pH 7.0 resonance stabilization. Factors affecting free energy of ATP hydrolysis: pH, magnesium ion concentration. Examples of other high-energy compounds. Coupled reactions, common intermediates. Substrate level of ATP hydrolysis. Substrate level phosphorylation. Phosphagens. Role of creatine phosphate as an energy source in muscle. Role of ATP in biosynthesis. Activation of building-block molecules in macromolecular synthesis	4
• **Energetics of carbohydrate and lipid metabolism:** Overview of metabolism. Catabolism and anabolism. Stages of catabolism. Respiration and fermentation. Energetic of glycolysis, efficiency under standard and cellular condition. Yield of acetyl CoA and reducing equivalents from β-oxidation. TCA cycle-energetic.	3
• **Oxidation-reduction reactions:** definition of oxidation, reduction, conjugate redox pair, standard form (if redox equation. Definition of standard redox potential, standard conditions and measurement of redox potential, uses of latter, Redox potential under non-standard conditions-Nernst equation. Mathematical relationship between ΔEo and ΔGo examples. Enzymes and proteins involved in cellular redox processes: pyridine-linked dehydrogenases, flavin-linked dehydrogenases and oxidases, iron-sulphur proteins, cytochromes, role of each in mitochondrial and extra mitochondrial oxidation.	4

• **Respiratory electron transport system and oxidative phosphorylation:** order of careers with experimental evidence. Effect of inhibitors, cross over points. "Sites" of ATP synthesis. Energy balance sheets for complete oxidation of glucose and palmitate. Efficiency of energy conversation. Mechanism of Oxidation phosphorylation. Uncouples. Ionophores. Inhibitors of ATP synthesis. P: O ratios. Mitochondrial structure and sub mitochondrial particles. Features of coupling factors. Oxygen uptake and appearance of mitochondrial in various states of respiration. Features of chemical coupling, conformational coupling and chemisomotic coupling hypotheses	4
• **Photosynthesis:** chloroplast structure, chlorophyll structure and absorption of light energy. Concept of photosynthetic units. "Collecting" chlorophyll. Pathway of electron flow from H_20 to $NADP^+$. "Z"-scheme, photo systems I. and II. Photosynthetic electron carriers and mechanism of phosphorylation. Comparison with mitochondrial oxidative phosphorylation.	2
• **Transport across biomembranes:** free energy content of transmembrane concentration gradients for uncharged and charged solutes mathematical relationship. Non-mediated and mediated transport, active and passive transport with some important examples	2

Assessment Tasks for Students during the Semester

Assessment task	Week due	Marks
1st continuous assessment	13/2/1440, 22/10/2018	25
2nd continuous assessment	19/3/1440, 27/11 /2018	25
Assignment and quizzes	Along the semester	10
Final exam	At end of the semester	40